U.S. 3 S58S v.3

SOIL CONSERVATION

HENRY A. WALLACE
Secretary of Agriculture

H. H. BENNETT
Chief, Soil Conservation Service

VOL. III • NO. 1 JULY • 1937

ISSUED MONTHLY BY THE SOIL CONSERVATION SERVICE, DEPARTMENT OF AGRICULTURE, WASHINGTON

SAND RIVERS OF CHINA

By W. C. Lowdermilk[1]

The Hwai watershed covers an area of 52,000 square miles. Its topography is unusual, for there is practically no divide on the north between this watershed and the delta plain of the Yellow River. Several times since 132 B. C. the Yellow River waters have broken the dikes and have spread over the land at the headquarters of northern Hwai tributaries and have usurped their channels. The most notable instance was the usurpation of the Hwai outlet to the ocean by the Yellow River throughout the entire 563 years, from 1289 to 1852 A. D. There must also be included in the northern portion of the Hwai Basin the bare mountainous area in southeastern Shantung drained by the twin rivers, the Yi and Hsu. Formerly these rivers flowed into the Hwai, but the deposition of silt by the Yellow River so elevated the outlet that they were forced to seek new outlets to the north of the original mouth of the Hwai. Thus, to the north the Hwai watershed except in Shantung is a great plain, with a very slight gradient and coalescing with the delta plain of the Yellow River.

To the south and west, however, the land area which drains into the Hwai is essentially mountainous. The Tsing Ling Range of Shensi makes a great bow or crescent; from western Honan, swings southward, then eastward. The eastern point of the crescent terminates in low, partially buried hills near the southern shores of Hung Tse Lake in northern Kiangsu. These mountains are composed chiefly of old igneous rock formations, and granite plays an important part and influences the erosion problems of the vast area.

An example of the temple (grave) forest and of the primeval forest cover. Dense growth of native oaks and shrubs.

[1] Associate Chief, Soil Conservation Service, Washington, D. C., formerly Research Professor of Forestry, University of Nanking, China.

153139—37——1

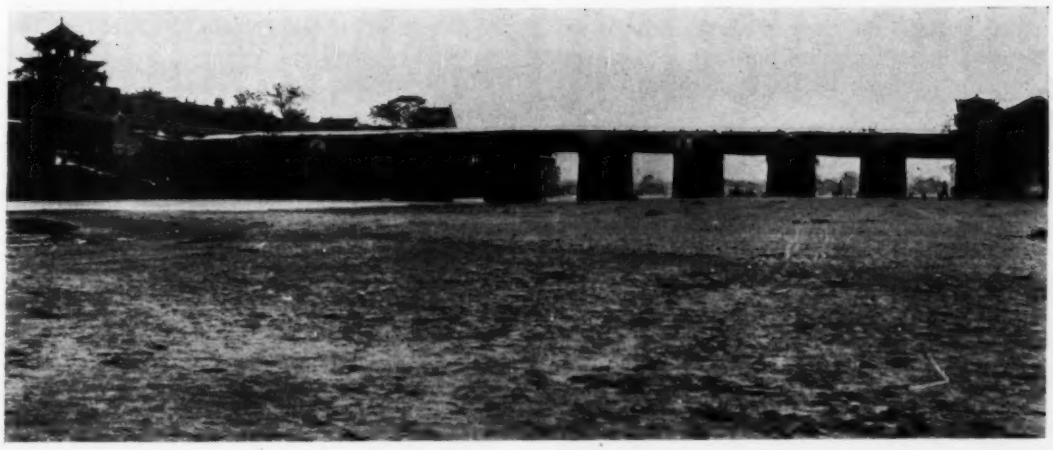
To the east the Hwai River finds itself blocked by the extensive silt deposits of the Yellow River which causes confusion in discharge of its waters, partly through the grand canal and partly through lowland lakes into the Yangtse River.

Temple Forests

To envisage what has taken place in the extensive mountainous region to the south of the Hwai River, mountains which doubtless contribute the major quantities of water for the Hwai floods, it is necessary to contemplate the primeval condition of the land surface. It implies a consideration of the type and extent of the cover of vegetation which the first human occupants of the region found. Fortunately, samples of this former vegetation are preserved in the temple forests, which the Buddhist priests, particularly, have jealously and religiously protected from annihilation. Likewise, graves of important personages, and of clans, have been so protected as to preserve exemplary growths of the native tree and shrub species. The forest of the ancient temple of Shui Ging An, at the headwaters of the Pi Ho, a tributary of the Hwai, may serve as a specimen of the primeval growth which long ago covered the mountain slopes of a vast region. Here are found the *Liquidambar formosana* and the oak as dominant species. The Liquidambar trees exhibit excellent development, reaching dimensions of 54 inches in diameter and a height of 125 feet. Oaks, likewise, reach splendid proportions. Bamboo played an important part in the vegetation, and doubtless in the primeval conditions it competed for place with the arboreal vegetations. Secondary species found in the temple forests are Tung Oil tree, *Aleurites* sp., *Celtis* sp., *Acer* sp., *Cunninghamia lanceolata*, and *Pinus massoniana*. The shrub and low growth is rich in species and densely covers the ground. In open spaces a very coarse vigorous grass, *Miscanthus sinensis*, Anders, first takes possession of the ground. It forms a dense and complete covering, but gives way to forest growth when in the course of time it is shaded out by overtopping vegetation.

Conquest of the Forests

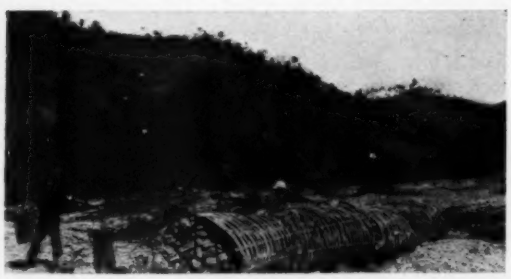
Thus, the first human inhabitants who penetrated the region south of the Hwai River doubtless were confronted with a dense, dark, and terrifying wilderness of forests which harbored ferocious animals. The conquest began and has proceeded through many centuries. Today practically no part except a few of the relatively small areas of temple forests has escaped the agricultural conquest of human inhabitants. Either



The Hu River and its bridge, at Kwangchow. It is said that 70 years ago the sailing junks of the Hwai moored here regularly and that the place resembled the port of Peng Pu. Now no sailing boat can reach Kwangchow owing to the sand-filled condition of the river channel.

the original cover has been cut, burned or destroyed and the subsequent growth subjected to some method of treatment, or the underlying soils have been entirely cleared or cultivated. Today, on these sloping lands, bared of their forests, the cultivation of corn and wheat, tea, and China root crops goes on.

The progressive baring of the mountain lands has produced a corresponding progressive change in flood



An effective device used in Anhwei to divert the current of a mountain torrent.

plain deposits from the blackish blue clays to brown and yellow superimposed silt and sandy silts found along the rivers, and finally is chiefly responsible for the rivers of sand which have been set in motion and are working their way northward down the tributaries and eastward down the Hwai River proper. The sand has reached Wu Lung Chi on the Hwai, and has reached the Hwai at Cheng Yang Kwan from the Pi Ho.

These sand rivers are believed to derive the vast quantities of sand partly from the general sorted deposit from the erosion of the mountainous areas of igneous rocks in recent geologic time, and partly from the accelerated erosion following the general

Pine trees alone do not necessarily prevent erosion of the upper soil layers.

baring of the slopes through cultivation within the past millenium and more particularly in the past five centuries. Evidence points to a marked acceleration in these processes during the past century.

A view of the landscape to the east of the Ma Pu, showing the state of slope cultivation, chiefly of tea.

These rivers of sand fill the channel of the Hwai and its tributaries, causing local overflowing of flood waters, and in their downstream movement will in time progressively jeopardize the permanency of costly engi-

neering works in the lower Hwai. Particularly will the sand, unless controlled, interfere in time with navigation and with the ample discharge of flood waters to the sea.

Near Ma Pu, a thriving little city in the Pi Ho Basin, the quantity of sand in the river valleys is inexplicably great. The valleys are wide stretches of sand with abrupt banks of igneous and metamorphic rock. The width of the valleys is remarkably out of proportion to the drainage area for a moist climate. The valleys are wide; they present the appearance of old arid valleys filled with sand. The little isolated igneous rock mountain surmounted by a temple, called Tu Shan, which lies 30 li up the stream from Lian Ho Ko, rises as an island out of a sea of sand. It is 150 feet high and lies surrounded by a sand plain 1½ miles wide. In this plain where flood waters can be diked off the sand has been built up and reclaimed first with the planting of willows. In time sufficient humus is produced to make cultivation of crops, with fertilization, possible. The sand therefore where not annually inundated is reclaimed and used for farming.

Tea Culture

The topography of the region about Ma Pu is picturesque. It is characterized by deep steep-walled, incised valleys, and high irregular mountainous sky lines. Only a small fraction of the landscape lies as level land in the narrow alluvial plains of the streams. The slopes are accordingly cultivated to yield first the tea, whose special quality has brought renown and profit to this section, and then the field crops for food supplies.

The culture of tea has become destructive to the slope soils. No attempt is made at terracing the slopes. The only measure employed throughout the entire area to prevent excessive gullying is the cutting of slanting ditches along the slope, 10 to 30 feet apart, to lead surface run-off to side drainage of the fields. This device prevents temporarily the formation of gullies down slope through the tea plantations.

Erosion goes on apace, and the soils are thinned down by the annual waste until the slopes become unproductive. The loss of soil due both to soil creep from plowing and from wash is excessive. In the culture of tea it is the practice to keep the ground about the tea bushes bare of other vegetation, which on steep slopes causes rapid erosion. Likewise, the life of a tea field is limited to 30 years, this being due to the gradual and continual loss of soil through soil wash. Bench terracing, certainly, becomes the only allowable measure to provide for a sustained production of food crops and tea on sloping land.

In the southern Honan region of the Hwai watershed the culture of China root has brought about conditions which have accelerated the wash of soils from the granite mountain area. It is the practice to cut off the pine forest, to remove all vegetation and all root stocks from the plot to be devoted to the growth of China root. Then billets of pine 4 feet long and up to 4 inches in diameter are buried first under the surface of the sandy soil with only one set of ends visible. These ends are thereupon impregnated with the spores of the fungus. If the growers are fortunate enough to secure a "catch" of the fungus, the mycelia run through the wood and then send forth a fruiting body downward into the loose soil. The fruiting body has the appearance of a root, being blackish on the exterior, hence the name China root. The interior of the fruiting body is pure white, compact, and possesses the consistency of cheese. This is the product which has a high value and has achieved sufficient importance to make up a significant part in the customs trade.

It is the practice to grow only one crop in one plot each 20 years, since it is believed that a second crop will not grow satisfactorily. The tendency has been to clear the mountains progressively; to rob the soils of all reinforcing elements, and to expose them to serious erosion. So general was the cultivation of China root a few years ago that the erosion and resulting torrential flows had become of such serious proportions as to arouse the local inhabitants to its gravity. Within the past 20 years the local inhabitants have reduced the cultivation of China root, and at Shih Lian Tze, the center of the culture area, there is a saying "Cheated by the China root" and this would indicate that the growers themselves realize fully that the damage to the country through China root cultivation greatly overbalances the benefits from the product.

In China, truths which become generally recognized are frequently, if not usually, reduced to proverbs. The following local proverb will indicate something of the attitude of the aggregate mind of the region toward the problems of erosion.

> When mountain vegetation is devoured by iron cattle,
> When the sand bars have reached Chen Yang Kwan,
> The prosperity of Hwo Shan (Hsien) will end.

Iron cattle here are said to refer to the iron mattocks of the farmers who cultivate the mountains, especially for tea. The significance of the sand bar is the interference with navigation.

(Continued on p. 26)

MAINTAINING ENGLISH SOILS *in* "GOOD HEART"

by J. Everard Hosking N.D.A – F.L.S[1]

DURING a recent visit to Washington, D. C., I was honored by the Editor of Soil Conservation when he asked me to write an article for this issue. As one who regards the study and care of the soil as being fundamentally important to the welfare of mankind, I am pleased to have the opportunity of contributing something to emphasise the importance of a subject that has been neglected for many years in practice, if not in theory. The neglect is not confined to one land, nor are the consequences entirely confined to one people. Peoples recognise frontiers but soil has no such limitations. Soil wealth, the accumulation of generations, has been raided in many parts of the world

[1] The author holds the National Diploma in Agriculture (practice and science) and is a Fellow of the Linnean Society of London. He is a graduate of an agricultural college and a director in an intensively farmed estate of nearly 2,000 acres.

Fifteen sheep and lambs are maintained on this pasture of Kentish wild white clover and ryegrass, from April to October.

THE EYE OF THE MASTER

WITH proper allowance for the differences between the English and the American types of agriculture, Mr. Hosking's article is arresting and stimulative in the emphasis it throws on certain more or less neglected aspects of soil husbandry. It reminds us that "The eye of the master fattens the cattle"—that every single piece of soil must be studied and understood if it is to be retained and used to the best advantage.

There is no question that fertile soils and newly broken sod can be worked much sooner after rains than poor and overexploited soils in which there remains little organic material. It has been noted that heavily fertilized garden soils lend themselves to intensive cultivation more readily than fundamentally similar soils under field conditions. Newly broken swampland in northwestern Ohio responded readily to tile drainage so long as it was freighted with organic matter; once depleted, however, not even twice as many tile availed to keep the soil in condition to work. A recent report of the Missouri Agricultural Experiment Station, Bulletin 369, refers to the production of manure artificially in England, and makes interesting reading in connection with Mr. Hosking's contribution.

A large amount of erosion in the United States is a result of the demand for grain or concentrates for livestock feeding. Now it is possible, as set forth in Vermont Agricultural Experiment Station Bulletin 350, to obtain artificially dried grasses, cut at immature stages, which have many of the qualities of concentrates and offer an acceptable substitute for the feeding of most livestock. Even hogs will consume considerable quantities of such grasses, as shown by their eating of alfalfa hay. As more economical methods of drying are developed and the costs of soil losses become more apparent, it is possible that more extensive use will be made of perennial grasses and legumes in lieu of cultivated crops when there is a conservation advantage to be gained thereby. Such substitutes, properly handled, can be converted into ensilage. As pointed out in Research Bulletin 62 of the Nebraska Agricultural Experiment Station, feed so produced carries high vitamin values which help to produce winter milk comparable to milk produced from fresh green pastures.

—THE EDITOR.

Steep slopes slightly terraced for cattle and sheep grazing. Terraces accentuated by livestock use. Soil light sandy loam over chalk.

until a state of dusty desolation is reached. What was living and productive of more living things has been bled of its life and remains to add to the modern problems concerned with the disposal and utilisation of the derelict and waste. Exploitation has been, perhaps, greatest on the richest virgin soils where acres have been plentiful and cultivators comparatively few; the art rather than the science, of good husbandry has not been understood, or if understood, not regarded. I believe that there is more danger

Young cattle on young pasture of wild white clover and grasses. Chalk hill in background grazed close by sheep to maintain vigorous herbage. If neglected, bare patches occur and land becomes barren.

today of losing the art of soil cultivation than of being ignorant of soil science. Frequently, the art of a skilled cultivator dies with him whereas the facts of science are preserved in records.

The cultivator who possesses the art of good cultivation together with a knowledge of the facts demonstrated by soil scientists is the real soil builder. He recognises the fertile soil as a living complex and not an inert mass; the boundary between death or decay of one generation of plants in the soil and the life of another springing out of it, is very narrow. He strives to maintain and, if possible, to increase the vitality of the soil of which he has charge. These soil builders can usually be found in greatest numbers in localities where land is scarce in proportion to the population

Tethered sows with litters are moved systematically over the land.

it has to feed, and the art of cultivation is passed on as a necessity from one generation to the next. Since the Great War, in years with huge surpluses of food commodities and resulting uneconomic prices, cultivators in many lands have been forced to break the rules of good husbandry by producing crops out of the normal rotation from which they hoped to retrieve, at least, their costs of production. The fact that the bad effects of this misuse of the soil were not apparent for some years led them to continue the practice until today there are soil deficiency problems in districts where the exercise of good husbandry in the past had maintained and improved the standard of fertility. The deficiencies encountered in recent years are many and the results may be seen in the crops and on the

livestock fed on those crops—to say nothing of the other major effect, erosion.

The fact that the health of all living things is closely related to the health or vitality of the soil is not common knowledge, and there will be little chance of arousing much general enthusiasm for the care of the land until this truth is widely accepted. The subject shows signs of receiving more attention in different lands and it is very heartening to learn of the progressive work already done in the United States. In the British Isles, although soil deficiency is not yet a serious problem, there are such diseases as heart rot in swedes, milk fever in cows, and pining in sheep (similar to coastal disease of sheep in New Zealand—a mineral deficiency disease)—to name a few—definitely attributable to mineral deficiency in the soil and crops. These are all remediable by adding the necessary minerals to the soil. I have witnessed remarkable results from the addition of comparatively small quantities of certain minerals such as iron and calcium to the soil. The plant would appear to be the best medium through which the herbivorous animal can derive its mineral requirements.

A steep terraced slope.

Soil scientists have yet much to do before this complex subject can be reduced to an exact and workable science. They have already accomplished a great deal, which knowledge is being put to good use by the intelligent cultivator. In our present problems of soil building and rebuilding, we have much to help us from (1) scientific contributions and (2) the experience of successful cultivators of the past. In England,

Ewes and lambs folded on kale. Plowed and followed by cereal crop.

prior to the Great War, land was maintained in what is called "good heart" by the successful cooperation of livestock and the plough. The old Norfolk rotation (roots, barley, clover, wheat) formed the basis of good arable farming. It was varied to some extent but not to affect the principles of good husbandry underlying it. From the point where that system was first introduced can be traced a successful building up of soil fertility and improvement in livestock. I believe it is equally true to say today that there has been a steady decline in fertility since the period, during the war and post-war, where this system has been abandoned.

Wild white clover protects this roadside slope.

The underlying principle of this system is still accepted by all good husbandmen as the basis of good farming for the maintenance of soil fertility and healthy livestock. The aim is to maintain and if possible to increase, the organic content of the soil, appreciating, too, the value of livestock secretions in promoting soil vitality. Here the earthworm flourishes and contributes its share to the soil well-being. One crop in the rotation, usually the root crop, was heavily manured by the muck from the livestock yards, or the root crop was eaten off "in situ" by the sheep on a careful system of control in hurdles—moving the hurdles to fresh ground each day. This method of eating off crops "in situ" by animals is called "folding" to which reference will be made again later.

The straw from the cereal crop was always used in the stockyards to be returned later to the soil as farmyard manure, a very sound practice. To hear is good, to see is better, but to operate is best. The practical farmer reared in this tradition appears to possess an instinct for appraising subtle, but important, qualities in his land and livestock. The skillful farmer, by organizing the right cooperation between the soil, crops, and livestock maintains the health of all three. Since the war many of the old and well-tried systems have been knocked "out of gear" in the interests of assumed economy and the dire effects have first shown themselves where there is least reserve of stored fertility, and a great number of the younger generation of cultivators have not inherited any, or sufficient, of their forefathers' skill to enable them to recapitalize their soils—the problem has been aggravated by the low prices ruling for beef cattle. Agriculture owes much to cheap artificial fertilisers, but these give their best returns from living earth where moisture, bacteria, organic matter, sun, and air can all play their part, for it is well to emphasise that a fertile soil is a living complex and needs a wide range of material to maintain its vitality, and the vitality of the animal kingdom that depends on it.

In seasons of drought I have been impressed by the fact that fertile soils suffer least. Possibly two of the most important reasons are that the more luxuriant plant population inhibits surface evaporation together with a better retention of soil moisture due to the generous root system and humus content. These soils also drain better in wet seasons, and serious erosion is unlikely to occur where the particles are so well knitted by myriads of roots. Good farmers in England have always utilised the clover family as the legumes to play a major part in maintaining soil fertility, as well as to provide nutritious food for livestock. The red, white, and alsike clovers and alfalfa in low rainfall districts are used in short leys first to provide a fodder hay crop and then to be ploughed under and followed by a cereal. Wild white clover, the seed of which was first produced on a commercial scale in the County of Kent, was used formerly only in permanent pasture mixtures, but it is now being used much more extensively in short ley mixtures as it is found to cooperate well with other grasses and clovers, and its elaborate rooting system enriches the soil with nitrogen and organic matter.

I will give a brief and general account of the practices most commonly adopted by good English farmers in keeping up the organic content of their soils.

(1) Arable farms with beef and/or dairy cattle

Farmyard manure is ploughed into the soil and if necessary catch crops such as mustard are ploughed in. Grassland with an abundance of wild white clover is grazed for one or more years and ploughed in.

(2) Cereal farms—with perhaps sugar beet—with no or few livestock

Green manuring is practised. The ploughing in of catch crops such as mustard, vetches and lupins, also a clover crop, first cut for hay and/or seeded and ploughed in.

(3) General or mixed farms

Farmyard manure from stock yards is ploughed in. Green crops such as kale, swedes, turnips, vetches are folded (system mentioned earlier) by sheep, moved to a fresh piece of ground each day, after which the land is ploughed. Grassland folded by sheep, or chicken (in small movable pens), and alternately by cattle, then ploughed. There is usually an abundance of wild white clover in addition to the grass in such pastures.

(4) Grass farms

Here open-field cattle and sheep grazing is common, as well as the controlled grazing system or folding. On many hill and light land farms movable mechanical milking bails are used for economy and to distribute the animal excreta more evenly. Chickens are moved in small pens, systematically, over the pastureland. Grass silage is made from some of the surplus young grass, and a quantity of hay. A more modern method

(*Continued on p. 13*)

FIFTY YEARS' EXPERIENCE *Gives Japan* Simple, Effective Program

by B·S·Detwiler[1]

During the past 50 years the national soil conservation program in Japan has proved its effectiveness in checking soil losses from erosion. Regulated tillage, intelligent farm management, reclamation practices, and care for the steeper lands have yielded quick and convincing results, and this fact undoubtedly lends encouragement to the newer program of the United States. Except that procedure in revegetation is relatively simple and standard, the control methods in Japan are similar to those with which we are familiar.

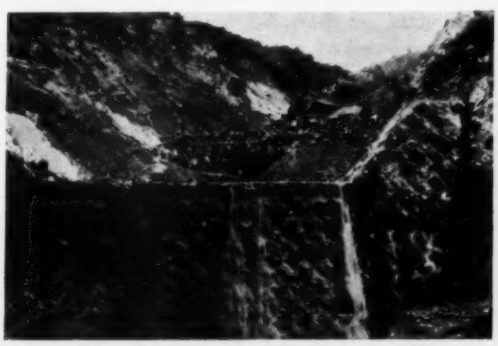
New light was thrown on Japan's plan when, not long ago, Mr. Kakuro Oshima, who is a member of the Forest Service, Department of Agriculture and Forestry, Tokyo, visited the Washington offices of the Service. Additional facts have been forthcoming through correspondence with Prof. S. Sakurai of the Department of Forestry, Faculty of Agriculture, Tokyo Imperial University. Professor Sakurai describes the general methods as follows:

[1] Head, Section of Hillculture, Soil Conservation Service, Washington, D. C.

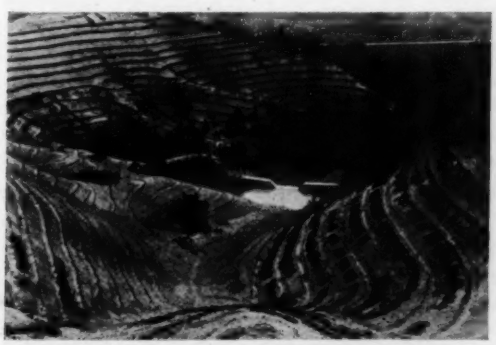
A planting of **Miscanthus sinensis** *and lespedeza bicolor. (Photographs by S. Sakurai, Tokyo Imperial University.)*

"In Japan eroded places are limited to mountain slopes where the mantles of vegetation have been destroyed by heavy rains or earthquakes. There is almost no soil erosion in fields because the fields are usually divided into many small areas.

"Now I will explain to you an example of erosion-control methods most commonly put in practice in Japan. In the torrential valley, dams and other constructions are made in order to prevent erosion by

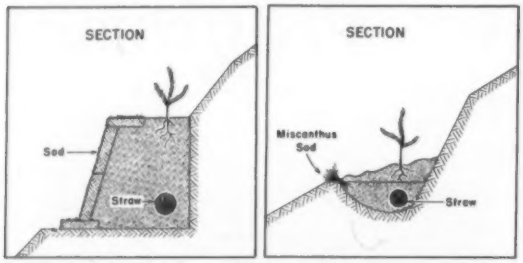


Engineering structures that attest the earnestness of Japan in her program to check soil wastage.



Erosion control has reached a high state of development in Japan.

establishing a base level. On the mountain slope that is steep and has irregular features, soil is graded down to the tenable gradient under natural conditions. Small horizontal shelves or terraces are cut in the slope, usually 1 or 2 meter contours. On this shelf, slabs of grass sod are placed as a retaining wall as shown in the following figures:



"Behind the sods, soil is pulled down from the slope above and tamped in place to a depth of 0.3–0.4 M. and a width of 0.3–0.6 M. On this shelf pines and alders are planted alternately with a distance of 0.5 M. Fertilizers such as calcium superphosphate, ammonium sulphate, ash, and straw of rice are sometimes applied.

"When the slope is not steep and mantle of soil is deep, the slabs of grass sod are omitted as a retaining wall, but Miscanthus sods are set along the front edge of the shelf."

A principal feature of the Japanese system which the writer believes may be of considerable importance to the work in this country is that erosion-control plants have been reduced to a very few species having outstanding qualities and wide adaptability. This has made possible a high degree of economy, both as regards the production of planting stock and in the erosion-control planting operations.

Only a few species of shrubs, trees, and grasses are used in initial erosion-control work in Japan. They are all plants which grow well on practically any soil or site, are readily planted, fast in growth, and cheaply grown as nursery stock. In particular, their root systems ramify so as to anchor the soil. The products of these erosion-control plantings are sometimes used for fuel or forage, but the Japanese consider that the primary function of erosion-control plants is to stop quickly the washing of the soil. If they serve this purpose well, their other values are of minor importance.

The species of trees and shrubs used are as follows:

1. *Pinus densiflora*, Sieb. and Zucc.
2. *Pinus thunbergii*, Parl.
3. *Alnus firma*, Sieb. and Zucc. var. *Sieboldiana*, Winkl.
4. *Alnus firma*, Sieb. and Zucc. var. *multinerva*, Regel.
5. *Alnus tinctoria*, Sarg. var. *glabra*, Call.
6. *Robinia pseudoacacia*, L.
7. *Lespedeza bicolor*, Turcz, var. *Japonica*, Nakai.

The second and fourth plants in this list are the ones most commonly used. Nursery grown seedlings, 1 or 2 years old and 8 to 12 inches tall, are planted. Any grasses growing naturally on the hillsides and having ability to stabilize the ground surface rapidly are considered valuable, but *Miscanthus sinensis*, Andress, is most suitable.

Robinia pseudoacacia is still used for erosion control, but, because of its shallow-rootedness it has shown poor results when planted on steep hillsides where the soil is not deep or where wind attack is severe. The wood of this species is used mainly for fuel; other uses of it are being tested. Its leaves are used for forage and green manure. The abundant spring growth after the trees are cut down interferes with the growth of the coniferous trees desired to replace the locust, so that this species is not so widely used in erosion planting as formerly.

Erosion control has now reached the high stage of development in Japan where the only serious erosion problems are on steep, nonagricultural lands. These lands are being reclaimed and maintained for the production of forests, chiefly soft woods (pine and cedar). It was emphasized by Mr. Oshima that in carrying out the dual objectives of erosion control and forestry on erosive lands, they had found it most effective to manage and conduct these operations separately on the basis of their clearly designed purposes. Accordingly, the reclamation and stabilization of the soil which embraces both the engineering and vegetative phases of erosion prevention and control is planned and directed by the soil conservation experts with the uncompromised aim of speedily qualifying the eroded areas for productive use. When this has been accomplished, the land is turned over to the land-use agency responsible for crop development and proper management of the reclaimed land. The outstanding success of this feature of the Japanese plan recommends it for our consideration.

COMING ARTICLES

No single issue of this magazine can attempt to give a world picture of soil conservation activities. Much valuable material on conditions and programs in other lands is in the editorial basket and will be presented in future issues as space will permit.

Sybaris: An Example of Watershed Control in Operation

By Arthur C. Ringland[1]

In the May number the general policies and principles underlying the Italian national land plan, or "Bonifica Integrale", were outlined. It was emphasized that a watershed becomes not only a project for flood control but a unit of land planning and administration within which all resources are developed to serve their highest usefulness. The Sybaris project in Calabria is an excellent example of projects which I inspected in Italy.

Hellenic settlers founded Sybaris in 700 B. C. It became the most opulent of the Greek cities and its citizens were known for the splendor and luxury of their living. And so "sybarite" became for all time the synonym for a luxurious person. For years Sybaris flourished, eventually to be wasted by war and eliminated by pestilence and floods.

Marshes Created by Slope Erosion

It is not possible to establish chronologically the manner in which the Sybaris area reached its present state of abandonment. There is little doubt, however, that the progressive erosion of the slopes of the surrounding mountains was one of the principal causes. These mountains, largely deforested, and subjected to unremitting pasturage, almost everywhere show damage accelerated by the geological character of the soil and the steep nature of the terrain. Thus, after every rainfall, even though brief, the meager works of protection attempted in the past were seriously menaced and often completely carried away. The flood waters inundated the lowlands, creating marshes and only through slow seepage reached the sea. Until the present project was undertaken a conception of the problem as a whole was lacking and there was no attempt to impose a complete solution in its two-fold aspect of sistemazione dei bacini montani—regulation of the mountain watersheds, and of bonifica della pianura—reclamation of the plains.

The Sybaris project includes a natural economic unit embracing the tributary watersheds of the Crati River between the slopes of Mount Pollino and the Sila Greca Hills and the Gulf of Taranto. The work may be divided into four phases—the conservation works in the mountain watersheds, the reclamation work of the plains, the improvement works for intensive cultivation and settlement, and finally the work of malarial control. These works in accordance with the cardinal principles of Bonifica Integrale are undertaken as a unit operation.

The denuded slopes are planted to American locust, a feature of the control work on the watershed of the Torrent of Grammasati, Calabria.

The total area—compresorio—of the project to be conserved and reclaimed is divided into the mountain and hilly area of 347,443 acres, and the plains of 79,099 acres, a total of 426,542 acres in all.

For the purpose of conservation the mountain area is divided into three sections averaging in altitude from

[1] Chairman, Flood Control Coordinating Committee, U. S. Department of Agriculture, Washington, D. C.

2,300 to 3,300 feet and ranging to a maximum of 6,600 feet, and is clearly defined by hydrogeological characteristics, extent of deforestation, and exploitation for cultivation or pasturage by sheep and goats. Two of the sections, the northern and the southern, where calcareous and clay soils predominate, and where exploitation has been intensive, show in most of the watersheds a general and menacing condition of erosion. Conditions are less threatening in the centra section where the streams are constant and carry down only fine material in suspension.

Stream-Bank Sliding

The mountain streams present three phases characteristic of this part of southern Italy. Ordinarily the stream beds, temporarily choked with debris, are dry throughout the greater part of their length with only a slight trickle of water in the upper reaches. During the rainy season from November to March, however, a small vein of turbid water begins to creep on the surface of the streambeds. In the second phase the streams flow tranquilly with but a slow erosion of the beds. It is the third phase, much more brief than the two preceding, that presents catastrophic characteristics. A sudden rainfall, of even moderate intensity, taking place during the rainy season when the denuded soils are already replete with moisture, provokes the sliding of entire slopes. Enormous quantities of solid matter are carried toward the plains in a few minutes and the streams become rivers of mud thick enough to hold masses of rock in suspension. These masses, aggravated and augmented by the material brought in from the tributaries and confined between steep banks, carry along all obstacles encountered until they debouch on the plain.

The annual precipitation of the Sybaris region averages 48 inches, of which 40 inches fall between November and March. The period from May to October is one of prolonged drought. The east winds charged with moisture from the Ionian Sea cause the heaviest precipitation when they encounter the high barriers of the Pollino and Sila ranges. The other winds are comparatively dry. Observations of the Royal Hydrographic Office have been carried on since 1915, and within that period a precipitation of more than 7 inches in 24 hours has been noted. There is reason to suppose that the fall is even greater at times, for experience has demonstrated that the regulation of mountain watersheds must be of an extensive as well as an intensive character to be effective.

The plan of conservation works therefore includes the complete reforestation of the denuded lands of the high basins; fixation of the slopes exposed to landslides by means of grading, terracing, and consolidation with lattices and fascines, followed by successive sowings and plantings of grasses and trees to strengthen and bind the soil; prohibition of pasturage in all localities where such works are located and its regulation elsewhere; the prohibition of further agricultural exploitation in the high basins and on steep slopes; and the regeneration of deteriorated forests.

The intensive work consists of the construction of masonry dams of small dimensions at the foot of landslides, along the larger stream branches, and larger dams where it is possible to obtain holding areas for the deposit of soil carried down from the slopes. The flanks of the streams are also protected from gouging by networks of large stones. The intensive and extensive work now planned will necessitate the reforestation of 25,000 acres, the regeneration of 57,000 acres of deteriorated forests, the fixation of 2,500 acres of landslides, the construction of 950 dams for stream flow correction and control, and the building of 30 miles of trails.

The Sybaris plains are divided into two parts by the Crati River. This river is fed by a network of streams which often change their courses owing to the huge amounts of debris they bring down from the mountains. The clays which are found everywhere in the hilly and mountainous parts of the watersheds have been deposited on the plains during the winter floods, forming an impermeable bottom. As a consequence, thousands of acres of fertile soil have become permanent marshland and breeding places for the anaopheles mosquito.

To Control Waters

The most important problem of the Sybaris plains is the diversion of the waters. By building embankments along 62 miles of the lower courses it is planned to confine the "external water" from the mountain watersheds to their natural channels. The "high" or flood waters from the hills and lower mountain slopes are to be gathered into special channels and directed into the natural river courses; and, finally, the "low" waters of the plain itself are to be drained by a network of canals and ditches and discharged into the sea. This canalization involves 155 miles of construction.

The problem is a difficult one because of the enormous quantities of solid materials carried down to the

plains by the numerous streams and the River Crati. The necessity of curing the disease at its source through the "sistemazione" of the mountains is at once apparent. Normally it is considered that such work is a preliminary condition to undertaking the reclamation of the plains. In the Sybaris project, however, it was advisable to carry on simultaneously the conservation work in the mountain watersheds and the regulation of the water courses of the plains.

The improvement works consist of the construction of arterial highways supplemented by a network of secondary roads totaling 120 miles to afford an adequate transportation system connecting with the railhead at the new village of Sybaris. This village is one of eight model rural centers, each housing 500 inhabitants and designed originally to accommodate the workers on the project but later used as homes for the settlers. The improvement works also include a domestic water supply for the villages and an irrigation system adequate for the intensive cultivation of 17,290 acres. Finally, to eliminate as far as possible the danger of malarial infection all borrow pits excavated in the course of construction work and all depressions holding stagnant water will be drained and the American minnow propagated to feed on the mosquito larvae.

At the time of the inspection the Sybaris project had been under way for 4 years. It will take 10 years in all for completion. The work was started in 1928, and since that time about 25,000 acres or a third of the plain has been reclaimed, 3 model villages built, 30 miles of road constructed, and 4 of the 12 important mountain watersheds "systematized," employing a daily average of 1,500 workers and at times 4,000.

Financing Conservation

The entire project upon completion is estimated to cost $12,500,000, shared largely by the State and by the consortium of interested landowners. Such associations are generally organized for each of the important projects. Membership is compulsory if the owners representing the greater part of the area organize a consortium and under certain conditions even if but one-fourth of the land is represented. These associations have the legal character of public-utility corporations with the right to issue obligations and bonds, contract loans, and to levy upon the members for their individual share of the costs of the project. The contributions of the members are taxes upon the property of the contributor, and they are classified immediately after the land tax and the respective provincial and communal surtaxes.

153139—3

The conservation work in the mountain watersheds and the flood-control measures necessary for the principal watercourses on the plains, particularly the Crati River, are carried out at the expense of the State. The State contributes to the costs of the other types of work. In southern Italy where land development is particularly difficult the State's share is 88 to 92 percent of the cost of the principal reclamation works; 75 percent of the cost of building rural aqueducts for the main supply of potable water; 45 percent of the cost of installing rural electric power stations and from one-third to 38 percent of the cost of the erection of rural villages, building and improvement of farm roads, provision for local water supply, drainage, and irrigation.

Maintaining English Soils

(*Continued from p. 8*)

Chicken folding huts are moved systematically over the land.

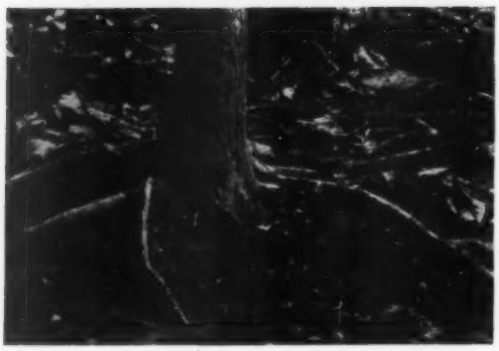
of utilising young grass and clover for cattle food is to dry them in mechanical driers—a growing practice.

Where folding is practised, it is usual to supplement the grass or green food by some concentrate. When a rich pasture is being folded, and the grass and clover are young and therefore rich in protein, it is customary to supplement by a carbohydrate food such as corn. If the crop is more advanced in growth a protein supplement may be necessary. The residue from these supplementary foods adds to the fertility of the land. A newer practice to be highly recommended as a means of adding organic matter and a large quantity of nitrogen to the soil, particularly after sheep grazing or mowing a pasture rich in true wild white clover where the grazing and/or mowing encourages a mass of stolons as well as roots, is to sow 200–400 pounds per acre of calcium cyanamide over the crop, disc and cross disc (disc harrow) to chop up the mass, and plough into the soil. The land is then in good heart for succeeding crops. In all the systems outlined

(*Continued on p. 28*)

The PUNJAB PLANS
A Coordinated Attack

by — Guy R. Stewart[1]



SOUTHERN and central India consists largely of rolling hills and valleys without high elevations and is separated from the northern ranges by the wide plains of the Ganges and the Punjab.[2] Beyond these plains the Himalayas rise with steadily increasing elevations that mark the division between India and the high plateau of Tibet.

The climate of India shows wide variations, being largely subtropical in the plains, with intense summer heat, but with moderate temperatures in the higher hills. With increasing elevations in the Himalayas there is a relatively short summer season and an appreciable winter snowfall which later melts and passes down into the streams of lower valleys. The rainfall likewise shows a wide range of variation, from practically desert conditions in Rajputana to high rainfall reaching well over 100 inches of precipitation in the Himalayas. Approximately half the annual rainfall in most localities falls during July, August, and Sep-

[1] Assistant to the Chief, Division of Research, Soil Conservation Service, Washington, D. C.

[2] This discussion of erosion conditions in India is based on material furnished by the following:

Glover, H. M., and Hamilton, A. P. F. Soil Erosion and Allied Problems. 4th British Empire Forestry Conference, South Africa, 1933. pp. 1–7.

Hamilton, A. P. F. Siwalik Erosion. Indian Forester, vol. LXII. 1936. pp. 375–387.

Gorrie, R. M. Notes on Soil Erosion in the Punjab. Manuscript communication. Indian Forest Service.

Sah, D. L. Note on the Afforestation of Jumna, Chambal, and other ravines. Manuscript communication. Indian Forest Service.

The accompanying illustrations are used through the courtesy of the Indian Forest Service.

THE PICTURES—Top to bottom

Sausage bund on Raidak River, Bengal. (Photograph by R. S. Troup.)

Famine laborers making ridges and ditches on a steep slope. Reclamation of ravine land. (Photograph by E. A. Smythies.)

Area unplanted and heavily grazed. Public forest, Shahpur division, Punjab. (Photograph by Fazaluddin.)

Pure plantation (1916) of Tectara grandis, *showing erosion due to absence of undergrowth and to burning. Upper Burma. (Photograph by H. G. Champion.)*

THE PICTURES—Beginning at top

Eroded slopes in the outer Himalayas. The erosion has been increased by grazing and cultivation. (Photograph by M. V. Laurie.)

The Sal jungle in Bengal is receding gradually and erosion has started, but on this rocky soil it is making slow headway. (Photograph by J. C. Nath.)

Afforestation in typical ravine country. (Photograph by E. A. Smythies.)

Afforestation has been under way four years on this ravine land. (Photograph by E. A. Smythies.)

Here is what ensues from heavy grazing. (Photograph by E. A. Smythies.)

tember, in what is known as the summer monsoon. April and May are generally dry and intensely hot. The autumn period is dry but cooler and in winter, in most places, there is relatively little rainfall. In northwestern India, the annual rainfall is lower and the valley of the Punjab, formerly considered a desert, has been irrigated by water drawn from the permanent streams of the Himalayas.

The Sacred Cow

Glover and Hamilton have pointed out as one of the most important factors affecting plant cover throughout India the fact that the Hindu population considers the cow as a sacred animal which must be preserved even though it becomes old and relatively useless. In consequence of this, nearly every village has herds of cattle which are often far more numerous than the villagers require. These herds frequently increase to the point where the district is unable to supply adequate forage for their nourishment. With the heavy Indian population there is little land available for pasturage and no regular meadows are ordinarily set aside for livestock. The cattle consequently graze on waste areas or in the edges of the forest, being driven up from

the villages by small boys or herders. In most cases, the cows are poorly fed and undersized. It is only in a few of the alluvial, irrigated plains that the stock is regularly fed in stables.

Teeming Population Reduces Cover

Throughout all the cultivated areas of India the population is extremely dense, even running as high as 1,500 people per square mile in the river plain of the Ganges. In consequence, the land holdings are small, often approximating only 3 to 5 acres for a cultivator. When a land holder dies, it is customary to divide his small farm among his sons, with the result that the subdivision of land is smaller than that of any of the countries in Europe.

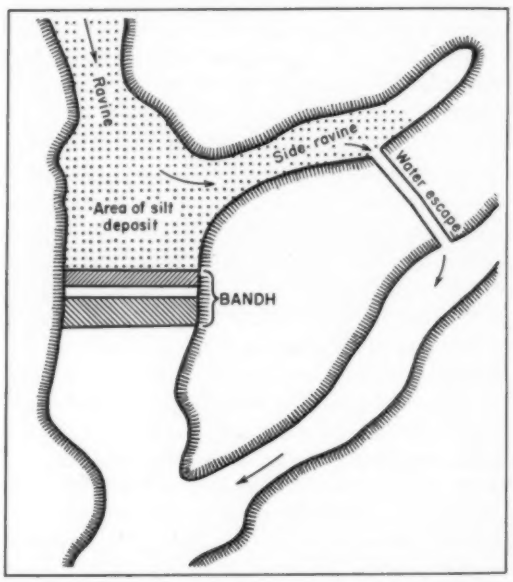
In addition to cattle, goats are kept in every village and are turned out to graze on herbage and small bushes from which the cattle have not been able to get any nourishment. In the mountains of the Himalayas there are large migratory bands of sheep and goats which are driven into the high pastures in the summer and in winter are moved down to utilize the vegetation on the already overgrazed foothills. In the lower foothills of the Himalayas, nomadic grazers have kept many herds of buffalo. With the demand for forage, all of the palatable, broadleaved trees are cut by the natives where they can reach the branches, and this again has tended to reduce the plant cover.

Himalayan Foothills Eroded

In a survey of erosion conditions made at the first meeting of the Crops and Soil Wing of the Board of Agriculture and Animal Husbandry in India, in 1935, it was pointed out that erosion was especially acute in parts of Madras, the Bombay Deccan, the outer Provinces, the Punjab, the central Provinces, Chhota Nagpur, and central India. Gorrie has stated that the most serious erosion is confined to the great belt of foothills and sloping ground extending for 1,600 miles along the main ranges of the Himalayas. This area reaches from the Siwaliks and the outlying rocky hills typical of Gurgaon in the east to the salt range in the west. The area involved is approximately 35,000 square miles, extending in a strip some 60 miles to 120 miles broad across this portion of India.

Silting Evidence of Erosion

Even outside of the acutely eroded area the effects of soil erosion have been evident in the silting of irrigation supplies resulting in the partial filling in of reservoirs and the clogging of irrigation ditches, to say nothing of the difficulty which has been caused by this sediment in operating many of the hydrcelectric plants. For example, the heavy load of silt derived from the Jammu and Gujrat foothills carried by the Jhelum River has decreased the carrying capacity of the upper Jhelum canal by 40 percent, even after the expensive installation of a number of silt ejectors.



Gorrie lists as the chief causes of erosion, (1) poor cultivation of unterraced or poorly terraced land with the undue extension of potato cultivation; (2) ab-

PUBLIC LIBRARY

normally heavy grazing of home and migrant flocks in the vicinity of villages; (3) seasonal concentration of migrant flocks along the travel routes leading to the alpine meadows of the Himalayas.

Forest conservation and replanting has been advocated as one of the most effective control measures for the badly eroded areas. However, up to the present time there are only approximately 5,180 square miles out of the total 35,000 square miles of badly eroded territory that are under the control of the Forest Service. Therefore, it will be necessary to go outside these areas if any effective reduction in erosion injury is to be accomplished. Until recently, the Punjab forest officers have advocated closure to grazing as the only feasible means of restoring the plant cover to its natural conditions and thus reducing the run-off and loss of soil. This will still be the main line of attack but it is now hoped to extend work under the Agriculture Department into a broader program of land use and land improvement which will deal with bad agricultural methods as well as overgrazing. Much of the present erosion loss has taken place in areas where no department of the Indian Government has made itself responsible for teaching and improving local practices. Projects have recently been outlined which call for close cooperation between the Forestry, Agriculture, Veterinary Science, Animal Husbandry, and Revenue staffs. The following program has been proposed:

I. To develop fodder resources for local livestock:
   - (a) Rotational closures.
   - (b) Partition of shamlat.
   - (c) Panchayat management.
   - (d) Intensive improvement of natural grasslands, including "gully plugging" to stop active erosion.
   - (e) Develop tree fodder supply.
   - (f) Develop green fodder crops and silage.
   - (g) Research on correct grazing incidence.
   - (h) Restrict nonright holders and immigrants' livestock.

II. To improve standard of cultivation:
   - (a) Better terracing and leveling of fields.
   - (b) Discourage downhill ridging for potatoes.
   - (c) Find good legume or grass crop to sow on fallow and plough in as green manure.
   - (d) Encourage use of compost manure.
   - (e) Control nautor grants (permission for fresh cultivation and refuse all for steep slopes.)
   - (f) Consolidation of holdings.
   - (g) Cooperative tree planting.
   - (h) Use of live hedge plants to replace thorn cutting.
   - (i) Contour drains in tea gardens and orchards.
   - (j) Stream training to reclaim cultivable land along torrent channels.

"Bandhs"—Unique Sedimentation Basins

In the past some of the most intensive schemes of erosion control have been carried out as a part of the programs of famine relief. Smythies[3] has given a detailed description of the methods employed in such an undertaking. In brief, the procedure has involved a combination of stream and gully control combined with replanting, together with the restriction of grazing in the treated areas. One of the principal features of this system of reclamation is the formation of sedimentation basins or "Bandhs" in the tributaries of badly eroded and gullied streams. The layout for one of these "Bandhs" is shown in the accompanying figure. The principle of the operation is extremely simple. It consists in putting well compacted earth dams across a tributary and cutting a water outlet in a higher portion of the stream so that excess water can have a chance to reach the main channel after it has deposited its load of sediment. This "Bandh" operation is combined with the development of many small terraced pits which are built out along the sides of the ravines and on the steeply sloping land.

Result of the deforestation of the hillslopes above government forest, Bhutan Native State. (Photo by B. C. Sen Gupta).

The idea behind the development of such a system of pits is similar to that of our methods of pasture ridging and furrowing. Water is impounded which would

[3] Smythies, E. A. Afforestation of Ravine Lands in the Etawah District United Provinces, Indian Forest Records, vol. VII. part VIII. 1920 pp. 217-249.

(Continued on p. 21)

The Transvaal bushveld in its natural state.

South African Problems Parallel Those of Great Plains

By Lois Olson [1]

Photographs by J. D. Scott, Department of Agriculture and Forestry, Union of South Africa.

In many ways the eastern two-thirds of South Africa resembles the central and southern Great Plains of the United States. Both are comparatively young countries and in both white population was superimposed upon a native nomadic population. The climate of the two areas varies from subhumid to semiarid. When it does occur, the rain is likely to be concentrated in heavy storms. Periods of drought and heavier-than-average rainfall occur at irregular intervals and may last for a few months or continue over a period of years.

The heavier rainfall encourages the areal extension of agriculture or grazing. Retrenchment and economic loss accompany periods of drought. During the more protracted periods of abnormal rainfall prophecies that the climate is changing are current. The initial settlement of the Great Plains seems to have occurred during a period of heavier rainfall and, in consequence, it was commonly believed that the rain followed the plow. In South Africa the rainfall of 1890–92 has not been equaled during the years following. This has led to the common belief that the country is gradually becoming drier, despite the fact that there is historical evidence of equally severe droughts in the past. In both regions overgrazing has resulted in a deterioration of the vegetation, erosion has reached the stage where it can no longer be adequately controlled by individual effort, and the respective governments have initiated coordinated attacks upon the problem.

Long before the coming of the white man the Hottentots and their cattle were well spread over southern Africa. Fire was their most effective tool for clearing land for cultivation, capturing game, and fighting their enemies. In consequence, it is probable that the background for erosion in South Africa was established before white settlement. The cattle trade of the Cape began in 1503 when Vasco da Gama, on his second voyage around Africa, succeeded in purchasing a cow and two sheep. From then on it was a port of call for all vessels rounding the Cape. Cattle and sheep continued as the chief export commodities of the Dutch settlers.[2]

[1] In charge, Erosion History Unit, Section of Climatic and Physiographic Research, S. C. S., Washington, D. C.

[2] For a comprehensive account of the pasture situation see: Hall, Thomas D., South African Pastures: Retrospective and Prospective. South African Journal of Science, vol. 31, Nov. 1934, pp. 59–97.

A farm in the Orange Free State reclaimed by the use of contour banks.

The agricultural area is limited in extent and maize is the chief cash crop. The country as a whole, however, has given up its dream of becoming a second Argentine. From the beginning of settlement, droughts were recognized as a limiting factor to agricultural development and by 1684, it was realized that a 2-years' supply of grain should therefore be kept on reserve. The trekking of the indigenous grazing animal was a result of drought conditions and 4 successive years of drought were basically responsible for the Great Trek of 1836. The custom of trekking which developed thereafter is directly attributable to overstocking during periods of heavier rainfall. By 1751 it was complained that there were too many European families in the country for all of them to secure an adequate means of livelihood. A little later, in 1775, Sparrman said that if the misuse of the land by both farmers and grazers continued "the presage of the country people may chance to prove true, viz, that many spots that are now inhabited and cultivated must be relinquished and suffered to lie waste." Similar complaints have continued and may be found even in current agricultural literature.

Equally important from the standpoint of land deterioration has been the custom of veld burning, traditional throughout much of the African continent and readily adopted by the white settlers. The serious consequences were obvious and in 1687, Simon van der Stel, of the Dutch East India Co., issued the first "placaat" which included penalties for starting fires. These were severe scourging for the first offense and "the cord until death do follow" for the second. The deterioration of the plant cover which followed burning resulted in reduced feed for the animals, overgrazing and finally the introduction of accelerated erosion. It is interesting to note that the drought of the 1860's was by many attributed to the wanton burning of the grass.

The deterioration of the native grassland was of concern at first because of its effect on the animal industries, and it was in this connection that studies of droughts were initiated. The association of both with the erosion problem was of later development. But basically the same causes are responsible for both the deterioration of the pastures and erosion and, in consequence, the cures may serve two purposes. For example, the customary system of kraaling precludes natural recovery of grazed pastures, soil and vegetation deteriorate in consequence, soil blowing begins, and the cattle trails create an erosion hazard. If, instead, the cattle were limited to fenced pastures with rotational grazing it would be possible for the vegetation to recover naturally and the danger of erosion would be reduced proportionately. Similarly, the improvement of pastures by the introduction of new species of grass or by fertilization could be made to accomplish two purposes. The value of such practice was recognized

by farsighted agriculturists at an early date and their general adoption was urged but, as in the Great Plains, the majority of farmers and cattlemen continued their old methods. Experimenting with the production of European grasses to improve the native pastures began during the latter part of the eighteenth century and in 1862 it was suggested that £10,000 to £20,000 should be spent for such tests at an experimental farm. Recommendations for the use of fertilizers also date back to the last quarter of the eighteenth century, but their widespread use is comparatively recent.

Erosion Control Initiated

The close association of erosion with the problems of drought and grazing may be said to begin with the publication of the Final Report of the Drought Investigation Committee in October 1923. Since then the investigation of the erosion situation has made rapid strides. In general this work is closely associated with efforts to reduce run-off and conserve moisture. The program has been approached from three angles which are equally important—education of the masses, research, and governmental control. It is realized that no amount of regulation will compensate for ignorance or apathy on the part of the farmers and that no controls can be effectively employed without their full cooperation. For the past few years practically every edition of the farm magazines has contained information on erosion. These may emphasize the dangers of erosion, the results of controlled experimentation, or the experience of farmers who have successfully checked erosion on their lands.

Ecological Investigations

The results of both experiment and practical experience show that, with few exceptions, vegetation must be regarded as the basic and principal weapon for fighting erosion and run-off. For this reason considerable attention is being devoted to ecological investigations, which include problems ranging from those of a purely botanical nature to the everyday problems of the farmers. Among these are problems of veld management and reclamation. Indigenous and foreign grasses are being studied to determine their pasture value, methods of propagation, breeding possibilities, and their relative value as soil binders and for retarding run-off.

To supplement the more theoretical studies, investigation is being made of eorosion under the various farm practices in general use in South Africa under similar soil, slope, and climatic conditions. Experiments have been made with corn, cowpeas, teff grass, Rhodes grass, bare ground both cultivated and uncultivated, natural veld, veld both grazed and burned, and close grazing not accompanied by burning.

Maize, the most important crop of the Union, is widely spaced and leaves a large proportion of the soil bare and, as replanting is necessary annually, the soil is completely without vegetal covering for a considerable portion of the year. In consequence, run-off during a 4-year test period amounted to 20 percent of the total rainfall, and was accompanied by rapid erosion. Cowpeas, when planted in widely spaced rows as is corn, are about equally conducive to run-off and soil erosion. Teff grass (*Eragrostis abyssinica*), an annual hay crop, has the advantage of providing several cuttings a year but is less effective than the sowed perennial Rhodes grass (*Chloris gayana*). It is urged that under no circumstances should the ground be left bare. In the case of planted grasses, it is the bare period at the time of resetting which is chiefly responsible for erosion losses.

Grazing and Burning

On the undisturbed veld both run-off and erosion are negligible. If the veld is overgrazed the run-off and erosion increase with the amount of grazing, but even this is far less harmful than the more common practice of grazing during the spring and summer and burning in the autumn. Under this type of management the run-off was 27 times greater than on the undisturbed veld during 1933–34, a year of good rainfall.

Of recent years the use of supplementary farm practices, such as contour furrows or ridge terraces, has received considerable attention. In South African Pastures: Retrospective and Prospective, Thomas D. Hall [3] cites examples of veld restoration accomplished by the use of the contour furrows. The stock-carrying capacity was increased, water was stored in the soil, and, as a result, springs developed where none had been before. Favorable results have also been obtained by the use of interrupted contour banks, but under different environmental conditions these may vary widely in size, spacing, and width and spacing of openings.

Government "Schemes"—A, B, and C

To encourage the establishment of counter-erosion works the Government has introduced three schemes under which farmers are subsidized for works approved

[3] See footnote 2.

Sheet erosion following removal of vegetation on the Transvaal bushveld.

and installed. Under *Scheme A* the work is carried on at the expense of the farmer, and the State pays a bonus of 33⅓ percent on the final valuation of all works for which application was made on or after April 1, 1936, up to a maximum of £250 per dam or £500 per farm, provided that one farmer owns no more than three farms. *Scheme B* enables the farmer to secure loans from the Department of Agriculture and Forestry at 3½ percent interest and repayable over a period of 30 years for the building of erosion-control works. The subsidy in this case is 25 percent with a £350 maximum per landowner. *Scheme C* was established to encourage the use of local unemployed European labor during the depression. The laborers are paid 5 shillings and 6 pence per day by the State, one-eighth of the cost to be refunded by the landowner without interest over a period of 50 years. The maximum payable is £350 per dam and £1,000 per farm. Since recovery has set in, the operation of *Scheme C* has suffered from lack of labor supply and farmers are being encouraged to change to *Scheme A*.

By the conclusion of the fiscal year ending August 31, 1936, nearly 13,000 dams at an estimated cost of £1,500,000 were approved under the three schemes. These serve the immediate needs of conserving water for drinking purposes and increasing fodder production, and by facilitating proper veld management, they help to prevent future erosion. During the same period, however, the value of works installed for reclamation and restoration of eroded areas (including contour banks, gully control, repairs, etc.) were estimated at somewhat less than £300,000, in spite of the fact that the need for such work is equally great. For this reason it may be necessary for the Government to grant aid on such a basis that actual reclamation can be properly achieved.

In planning for research and establishing erosion-control works, South Africa has recognized the similarity between environment in that country and in sections of the Great Plains of the United States and has utilized the results of our experience. Similarly, their experience may serve as a check on our procedure, suggest other methods for erosion control, and indicate new lines of research.

THE PUNJAB PLANS A COORDINATED ATTACK

(*Continued from p. 17*)

otherwise escape during periods of heavy precipitation. The earth composing the ridges surrounding the pits is carefully worked down into a fine mulch and used as a planting bed for a variety of forest seeds. The water impounded by the pit supplies sufficient moisture so that a relatively high germination is obtained by direct seeding of forest and foothill species. Smythies notes that in famine relief all members of the community, even small children and elderly people are given employment at a low maintenance wage.

Slowing the in JAVA and

by
Guy·R·Stewart

THE Netherlands Indies consist of a long and relatively narrow band of islands stretching across some 3,100 miles of ocean. They lie along the equator and extend from Asia almost to Australia. The greater part of these islands have a scattered native population. Java, the oldest settled member of the group with an area, including Madura, about equal to the State of New York, is an exception. This island possesses a dense population of some 41,500,000 people.

All the islands have a humid, tropical climate, although considerable variations occur with changes in the local topography. The temperatures of the lowlands show a seasonal range from 70° to 91° F., but with each increase in elevation of 500 feet, there is usually a decrease of about 2° F. in

THE PICTURES—This page

Upper left—In North Sumatra the land lies fallow seven years following one year of cultivation. No trees are planted, but the trim tobacco fields soon revert to jungle.

Lower left—As timber makes way for rice fields or plantations in lowlands, the need for firewood and building material results in the cutting of trees on neighboring hillsides. For years there was no thought of reforestation; as a consequence the heavy tropical rains exacted a terrific toll from the soil.

Below—Another view of barren Sumatran hillsides. European rubber plantations having preempted the valley lands, the mountains have had to furnish most of the timber in recent years. The Government is now having to take steps to conserve the soil.

Raindrops SUMATRA

average temperature. Owing to the proximity to the equator there is little difference between summer and winter temperatures, and this makes the change from the low plains to the higher mountains even more

THE PICTURES—This page

Beginning at the top.—Though often unsuited for the growing of rice, hillsides along motor roads are planted to other food crops. Here is to be seen a border of corn and manioc, with various other plants growing between.

On hillside or in valley, every area, however small, is made to furnish its quota of foodstuffs for Java's teeming millions. Not only do the terraces conserve the soil, but every drop of water is made to work over and over again before it is allowed to reach the sea.

Reforestation of the mountain districts, chiefly with **Pinus mercusii** *was designed to combat erosion, to conserve the quality of the soil, to prevent floods, and to provide both timber and turpentine.*

In the Outer Possessions, where the population is thin and relatively little attention is given to the production of rice, the fields are usually located in low spots where water may be easily conserved. In such cases little attention was formerly paid to the hills, except as sources of firewood and timber.

So important is the foodstuff situation in Java and so precious is every drop of water used in cultivation, that the Government has for many years been developing systems of dams, canals, and sluice-gates in order to supply water to the rice fields in the dry season.

striking. In addition to the decrease of temperatures with increasing elevation, greater cloudiness prevails in the higher hills and a heavier precipitation. In the mountains there are likewise a larger number of light showers instead of the heavy tropical cloudbursts of the lowlands.

The rainfall is relatively abundant in all the islands and few places receive less than 40 to 50 inches per year. Precipitation of 120 inches and more is not uncommon in the mountains of Java, Sumatra, Borneo and Celebes. The highest precipitation recorded is in one of the mountain valleys near Kranggan, Java. Here the annual rainfall ordinarily is about 270 inches.

Topography Unusual

Those two portions of the archipelago which have been most intensively developed, and thus exposed to soil erosion, are Java and Sumatra. Both islands are long and narrow, with strongly developed mountain ranges, occurring on the south coast of Java and on the west coast of Sumatra. The ranges are so placed that the rivers which run to the south in Java or to the west in Sumatra are rapid torrents with a steep drop. As a consequence, very little silting takes place along these streams, the currents being sufficiently rapid to remove any soil and debris and carry it out to sea.

In the streams running to the north in Java and the east in Sumatra, the courses of the rivers are longer and more winding. The streams may carry silt and at times form fertile, alluvial deltas; or they may even build up bars at the river mouths to interfere with shipping.

The central mountain ranges on both islands are extensive and thus most of the land is sloping or steep in character. Hence, agricultural operations have largely been adapted to steep or even precipitous hillsides.

The original cover on both islands consisted of a dense, tropical jungle of tall trees with rather light understory of shrubs and herbaceous plants. A variety of tropical hardwoods abounded. Along the coast a number of species of palms were found, as well as bamboo groves, and in swampy places, mangrove thickets occurred. While this heavy vegetative cover remained undisturbed practically no erosion took place.

One of the first points to be considered in studying the factors which have contributed to erosion are certain outstanding differences in the origin of the soils of both Java and Sumatra. On the island of Java, over two-thirds of the land is derived from the weathering of relatively recent ash or lava flows. These soils, often spoken of as the younger volcanic red soils, have been found to be notably more resitant to erosion than the older tertiary soils which occur over approximately one-third of the island. Rutten [1] has shown that this difference is clearly reflected in the quantities of silt carried by the rivers to the sea. In the streams flowing from the older tertiary formations he found amounts of soil which were equal to a soil loss of 1 millimeter up to 5 millimeters of the land area per year, whereas in rivers where the weathered soils have been derived almost entirely from the recent volcanic rocks,the amounts of silt were only equal to a loss of 0.1 to 0.4 millimeter of the land area.

The soils of Sumatra are derived from a greater variety of formations than are those of Java. There is a larger proportion of tertiary rocks which have weathered in some cases to form relatively sandy soils. These soils are extremely short-lived in their period of productivity. This high variability in the fertility of the Sumatra agricultural lands may account partially for the fact that native settlement in that island has not spread and increased from relatively early times with such rapidity as in Java.

In considering the productive life of the soils of tropical regions, such as Sumatra and Java, Mohr [2] has pointed out that the average soils deteriorate under cultivation at a much earlier period than is the case in Europe. He estimates that only 5 to 10 years are often sufficient to achieve the same reduction in the content of organic matter and productive capacity which may require 25 or 50 years with European agriculture.

Agricultural Systems Harmful

A second factor of great importance which contributes to erosion in portions of the Netherlands Indies is the system of land use. Mohr has noted that in the European Netherlands a farmer uses a small piece of land and at his death bequeaths this property as his most valued possession to his children. In the Netherlands Indies, on the other hand, the large plantation operator rarely remains more than 10 years on the same plantation and during the whole

[1] Rutten, Voordrachten over de Geologie van Nederlandsch-oost-Indie, pp. 127–129.

[2] Mohr, E. C. Tropical Soil Forming Processes and the Development of Tropical Soils. Trans. by R. L. Pendleton, pub. by National Geological Survey of China, pp. 1–200, 1933.

period attempts to obtain maximum production. The natives, in general, up to the present time, have not felt the same intimate sense of family possession which has been developed by European peasants through long generations of experience. The interest of the native is confined to the production of the soil for the period in which he uses it.

"Ladang" Cultivation

In newly settled regions in Sumatra and in the outer islands where much virgin land has been available, there has been a great deal of "ladang" cultivation; that is, cultivation of annual clearings that are deserted at the end of 1 or 2 years for further clearings of new land. In these clearings which have been used for a variety of agricultural crops, the natives seldom take effective measures to prevent surface denudation. This deterioration is partly due to the failure of the natives to use any soil-improving crops such as legumes, as well as to early erosion. In some sections of Sumatra it has been noted that an entire tribe would move into a valley for a season, burn down a clearing of trees and plant rice or corn, and after the harvest was completed, move on to another valley and repeat the process.

Plantation Havoc

Just previous to and since the World War, the European plantations, especially in north Sumatra, have expanded on an enormous scale, with thousands of acres of new plantations being established on jungle land each year. The trees were felled and burned and all vegetation was removed. The new soil proved to be extraordinarily rich and unusually porous, and growth of the planted crops in many places was excellent. The tropical rains, however, caused a rapid loss of soil which soon wrought havoc both in the fields in which it occurred and on low-lying lands to which the debris was washed.

The result of the combination—European plantations and native cultivation on the mountain sides—has been severe erosion in many parts of north Sumatra. The loss of soil soon attracted the attention of the planters and as the injury to lowland plantations from deforestation and upland planting increased, appeals were made to the Government for aid and assistance. This has led to an appreciable amount of reforestation of the hillsides in Sumatra and a very large amount of terracing of plantation areas.

Beumee [3] has pointed out some of the difficulties which have occurred in the cultivation of erodible tertiary soils of Java. In a region close to Cheribon on the watershed of the Tjikeroeh River, there is excessive erosion which appears to have started toward the close of the last century through pasturage and overstocking of carabao. This excessive use persisted for only a relatively short period, but on the impermeable subsoils common to the region there was a great deal of incipient erosion which led to a hummocky, almost gullied appearance of the pasture land. In some places, on the tertiary formations where the natives have attempted to install rice paddies on steep sloping land, there has been a slumping and sagging of the fields due to mass movement of the soil upon the relatively impermeable subsoil.

Erosion Prevention Measures

Probably the greatest factor responsible for protection of soils in Java and Sumatra is the so-called "sawah" system of wet-land rice agriculture. The success of this type of cultivation depends on a thoroughly worked and wet seed bed, in flat terraces, and growth under water until the crop is practically mature. The slow circulation of the irrigation stream is sufficient to prevent serious washing or loss of surface soil. Another factor which helps to reduce erosion is the intensive development of plantation terracing which has gradually evolved in both the islands. Since the recognition of destructive erosion in Sumatra, it is not unusual to see individual terraces for each separate tree on the rubber plantations. Various modifications of the system of terracing have also been worked out by the tea plantations for cinchona, cocoa, coffee, and the other upland crops.

Experimental Work

In addition to these practical developments for control of erosion considerable experimental work has been carried out, largely under the Forestry Experimental Station. Some of the work has been reported by Haan.[4] At an important experimental area on the slopes of the older Patoea Volcano south of Bandoeng run-off and stream-flow measurements have been made; and more recently, experimental installations were set up on an area of 150 hectares near Madja in the resi-

[3] Beumee, J. G. B. 1936. Manuscript "Communication on Soil Erosion in the Netherland Indies."

[4] Haan, J. Hde. Boschhydrologische problemen en onderzoekingen op Java. Tectona XXVI 1933 pp. 1–56.

(Continued on p. 28)

SAND RIVERS OF CHINA

(Continued from p. 4)

The proper use of trees to protect dikes. A growth of willows, which will stand submergence provided the crown is above water, is a very effective way to reduce the impact of currents against dikes.

In southern Honan, at the headwaters of the Ma Ho, a secondary tributary, one may find this proverb:

Mountains empty,
Rivers gorged.

It is supposed to mean that when the mountains have been deprived of vegetation, the streams are filled to overflowing with sand. The figure is that the rivers have eaten to their full. These and other local proverbs are evidence which is of even greater importance than the judgment of individual men. In order to crystallize thought into a proverb, processes must have reached a degree which not only has attracted the general attention but has produced a consensus of opinion regarding them. These proverbs, therefore, are believed to indicate that erosion of the mountain lands has reached an advanced state.

"Mountains Empty"

The sand deposits and the movement of the sand down the streams of the Hwai system appear from the evidence to have been in motion only a comparatively short time. Evidence indicates that the sand is moving down the stream channels at the rate of 3 to 5 li or 1 to 1½ miles in some years. For it is probable that the rate of movement is not uniform but irregular. The sand deposits, therefore, manifest an extensive area in the watershed of these mountains which has been bared to the direct wash of rain water run-off. Yet the quantity of sand is too great to suppose that it is the direct result of cultivation within as long a time as the past five centuries. It seems more probable that much of the sand had accumulated near the slopes of origin simultaneously with the laying down of the clay deposits. But it doubtless was set in downstream movement in very recent times by unusually powerful currents of run-off which the baring of a landscape to excessive erosion would produce. It seems possible thus to explain how previously accumulated supplies of sand are being washed down the stream channels by increased torrential flows of run-off water as a result of extensive denudation of sloping lands within the watershed.

The removal of the vegetative mantle from the Hwai watershed slopes is more satisfactorily ascribed to the results of human occupation than to a change in climate, particularly since the present climate suffices to produce a dense and complete cover in unmolested regions typified by temple forests. The present extensive cultivation of sloping lands on gradients up to 100 percent is held responsible for the lack of a complete mantle of vegetation as well as for the acceleration of erosion above the erosion norm of the region and for the increasing amounts of coarse and sandy sediments which are moving down and filling to overflow the river channels.

Today the problem of the vast Hwai Basin is twofold: First, the sand rivers which are working downstream to fill up the main channel; and, second, the serious erosion at the headwaters of the tributaries and of the Hwai proper. These problems can be approached with hope for success only after the preliminary cover and erosion surveys already made are extended to the whole watershed to determine what tributaries deliver the bulk of the flood waters and the rate of erosion, shoaling, and the necessary corrective measures. It will be necessary, also, to measure the rainfall in the mountains, which will involve a continuation of the present meteorological stations and the establishment of additional stations whereby the mountainous areas will be equally represented with the plains.

Continuance of the study of the hydrology of the Hwai is extremely important and should include the establishment of stream gaging stations on the tributaries and the Hwai proper at strategic locations. The measurement of the silt content of the run-off waters should be made at these stations with the object of determining the rate of supply of sand to the streams, the movement of the sand downstream, and possible and practicable measures for controlling the excessive erosion. The study of the sand now in motion is particularly important because of its effect upon the permanency not only of transportation on the Hwai but of the permanency of the conservancy works

which must be employed to drain the flood waters rapidly to the sea.

Once the surveys and installations are completed, it should be possible to set in motion operations for feasible measures to control the erosion at the headwaters of the tributaries and of the Hwai proper. With the erosion-control measures established, increased values and enlarged revenues from reclaimed agricultural lands should balance engineering costs.

With regard to the temple forests and enclosures in China, their importance as areas for measuring experimentally the distribution of rain water into run-off and infiltration cannot be overemphasized. These temple forests are of tremendous scientific value to China and should be protected from molestation in the way of clearing and cultivation of the soils. In fact, the temple forests would make excellent sites for experiment stations to which should be added an area of adjacent cultivated lands on which comparative studies might be carried out.

Erosion control in the great loessial area of China is a tremendous task. It should be attacked first in an experimental manner, with intensive appraisals and studies of surface erosion conditions, gullying and river bank and river bed erosion. Soil studies will determine the kinds of vegetation suitable to the various localities. Not the least important is the problem of radical change in farming systems which will need to be introduced before slope reforestation can be developed to any remedial degree. It is fully realized that the present population engaged in the production of tea, China root, corn, wheat, and rice, shrub and small tree timber for fuel, cannot be expelled from the lands for the long period required for the planting and growth of permanent forests.

Plan Taking Form

In no sense can it be said that the Chinese people are unaware of the serious condition of their lands and waters. Slowly but surely, in spite of extraordinarily unsettled political conditions, banditry interference and inadequate financial support, the plans for conservancy operations are taking form. In a letter received recently from Mr. S. Eliasson, of the Yellow River Commission, he states that funds have been allocated for a few experimental soil erosion control stations, and that the hydrometric work on the Yellow River is yielding some extremely interesting data. To quote Mr. Eliasson, "Since 1932 the rainfall in northwest China has been above average. Floods in

An eroding slope which was formerly in forest cover. Where the culture of China root has been practiced, erosion has taken place.

the Yellow River were serious during all the following summers, but the silt percentage in the run-off has been gradually diminishing. There can be no question in my mind that the cause for this is the steadily increasing vegetation cover due to the greater rainfall." With changed farming systems and land use, giving vegetative cover a chance to establish itself, the same results may be noted within a surprisingly short time in the sand rivers that form the Hwai system.

Under the leadership of Mr. Eliasson, K. C. Hou, chief of the Soils Division of the National Geological Survey of China, M. S. Chang, Forestry and Reclamation Department of the Yellow River Commission, and others, the Chinese are anxious to pattern their soil erosion control program after the one now well under way in the United States. In Mr. Eliasson's article, Soil Erosion and River Regulation, published in the Journal of Chinese and American Engineers, the following paragraph gives us an idea of the plan now under formulation:

"Ploughing along contours on sloping, non-terraced ground will have to be adopted in order to hold the rainfall so that it does not tend to carry off the top-soil or develop gullies. Strip cultivation will have to be introduced whereby strips of erosion-resisting plants alternating with parallel rows of cereals will provide additional safety against surface wash of the soil and gullying. Special consideration will also have to be directed toward the areas near the foot of the mountains where the rainfall comes rushing off the mountain side or down the gullies, tearing away the loess cover. But here there are good materials to work with to make drift and check barriers and there is no doubt that this phase of the problem can be successfully tackled. It is being handled successfully in America. Why not in China?"

BOOK REVIEWS AND ABSTRACTS

By Phoebe O'Neall Faris

CONSERVATION OF THE SOIL. By Dr. A. F. Gustafson. New York and London. 1937.

Here is the newest text on current work in the field of erosion control, written by a professor of soil technology, which emphasizes decidedly the agronomic viewpoint. While all types of erosion are covered the author is especially concerned with the introduction and maintenance of protective vegetative cover for the soil and the kinds of crops applicable to this purpose. As a text for schools, for landowners and operators, or anyone interested in checking land wastage, the book is admirable since it presents the general picture in a simple manner and gives definite information for planning and applying soil-conservation methods. The discussion of erosion by actual volume of soil, by plant nutrient value loss, and by destructive deposition, is excellent from the standpoint of popular educational needs.

As to natural factors affecting erosion of the soil, special attention is given to precipitation distribution and intensity and the importance of long-time detailed rainfall records for planning soil-erosion control on arable lands and for flood protection. The subject of latitude as influencing erosion is treated briefly, the main idea being that rapid thawing of unprotected soil, if accompanied by warm rains, results in serious loss of topsoil.

Rather extensive treatment is given to slope and soil type as affecting rate and extent of erosion under varying land cover and utilization conditions. Various soil characteristics are discussed as to size of particles, tilth and porosity, depth and water-holding capacity, subsoil absorptive capacity, and uniformity of composition. In a section dealing with vegetative cover as protection against erosion some interesting tables are included to show effects of different types of cover on losses of soil and water. The treatment of crops and tillage as affecting erosion contains some general statements regarding the use of hay crops, small grains, pastures, rotations and fruit crops as opposed to the continuous cultivation of clean-tilled crops which may be classed as educational material for schools rather than as advanced studies for the trained conservation technician.

The greater part of the book is given over to a description of practical measures for the control of soil losses through erosion. "In a broad general way", writes Dr. Gustafson, "the most important single factor in preventing erosion is the production and maintenance of a complete vegetative cover for the soil. * * * The maintenance of the organic-matter content of the soil, fertilization and liming for the production of good crop yields and an adequate vegetative cover for the soil, contour tillage and seeding, and contour strip cropping are essential in any complete soil-erosion control program under normal conditions. For control of erosion under abnormally high-intensity rainfall, however, the use of interception or diversion ditches and terraces, in addition, is of utmost importance in many sections of the country. In fact, reasonably complete control of erosion, especially under the less favorable conditions, can be hoped for only when all the known control measures are applied intelligently to the entire soil-erosion problem."

For maintenance of organic matter in the soil, the author emphasizes the importance of using barnyard manures, crop residues, green manures, cover crops, and the following of a definite rotation plan. Considerable experimental data from various stations is given in support of cover crop and rotation systems suitable to the soils, climate, and feed- and cash-crop requirements of separate regions of the United States.

Much of the material on principles and precautions of erosion-control methods is credited to the Soil Conservation Service. Adaptation of method to soil type is stressed as of utmost importance in planning for contour tillage and planting. For developing a suitable system of strip cropping it is recommended that the soil conservationist obtain all data possible on the agricultural set-up of the area in which he is working, and in addition that he compile climatic charts, soils and slope and cropping maps, and that the projected strip cropping lay-out be superimposed upon the crops maps.

MAINTAINING ENGLISH SOILS

(*Continued from p. 13*)

above, appropriate artificial fertilisers are used in addition, and their efficacy is most apparent on soils organically well built. Large quantities of factory by-products such as shoddy (wool waste), hoof and horn, bone, etc., are used particularly on market garden and fruit farms, hop gardens, etc., or where farmyard manure is not available.

The cultivator's growing concern for the welfare of his soil is being shown in England at the present time by increased interest in methods of composting (controlled decomposition) in specially made heaps, all forms of waste organic material from hedge trimmings and cereal husks, to Autumn leaves.

The selling of such products as milk, mutton and lamb, cereals, etc., off the farm is a constant drain on the soil's resources, and in countries where there are elaborate sanitary drainage systems this loss is a real one to the land for at least a generation, as valuable plant food is directed away to non-productive areas or to the sea. Better use should, and could be made of liquid manure. Barren districts of low rainfall, and other infertile areas, could be built up gradually in fertility by growing crops stimulated and watered by liquid manure. At first, any plant that could be established there should be encouraged in order to produce organic matter for ploughing in to build up the soil.

It may not be too much to hope that future health schemes will be comprehensive enough to consider the importance of soil vitality.

SLOWING THE RAINDROPS

(*Continued from p. 25*)

dency of Cheribon. These installations are on clay shale and tuff soils which are extremely susceptible to erosion. In addition, the Forest Experimental Station is carrying out studies at a number of other mountainous regions in order to determine the susceptibility of various types of upland soils to loss from erosion.

U. S. GOVERNMENT PRINTING OFFICE: 1937